# Individual Lab Report #9

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**Individual Progress:**

During the past two weeks, I mainly worked on:

1. Map the new testing area.
2. Make CuBi able to localize inside the new testing area, by utilizing the map with a variant of particle filter.
3. Fix remaining issues.
4. Integrate the new map and the localization subsystems with other existing subsystems.

Last week, we confirmed a new testing area located near the MRSD lab, on NSH B-Floor to perform our routine testing and FVD. In order to make all the subsystems work together, a map of the environment is one of the important bridges. Therefore I worked on mapping the new testing area during the past week.

Same as before, the Hector SLAM package is used to map the room. The input is Hokuyo LiDAR scans, and all essential static frame transformations, such as the transformation from LiDAR to the robot base. During the creation of the map, I used joystick to slowly move the robot around the room, without aggressive translation and rotation movements. Otherwise frame-to-frame scan matching will likely fail. The figures below illustrate the testing area, and the map built. The map server package is used to save the map to local hard disk, and also to load the map every time it is needed by other subsystems.

After having the map, we can then perform localization of the robot with respect to the map, starting with an unknown initial position. This is also known as "global localization". With this feature, we do not restrict CuBi to start at a fixed location every time, and it can localize itself autonomously.

One of the most popular approaches to this problem while having the map and wheel odometry available, is the particle filter. I utilized a variant of particle filter, the "Adaptive Monte-Carlo Localization" (AMCL) package available with ROS. By setting up the configurations with respect to our robot, it is now able to localize itself in our testing area, even with an unknown initial position.
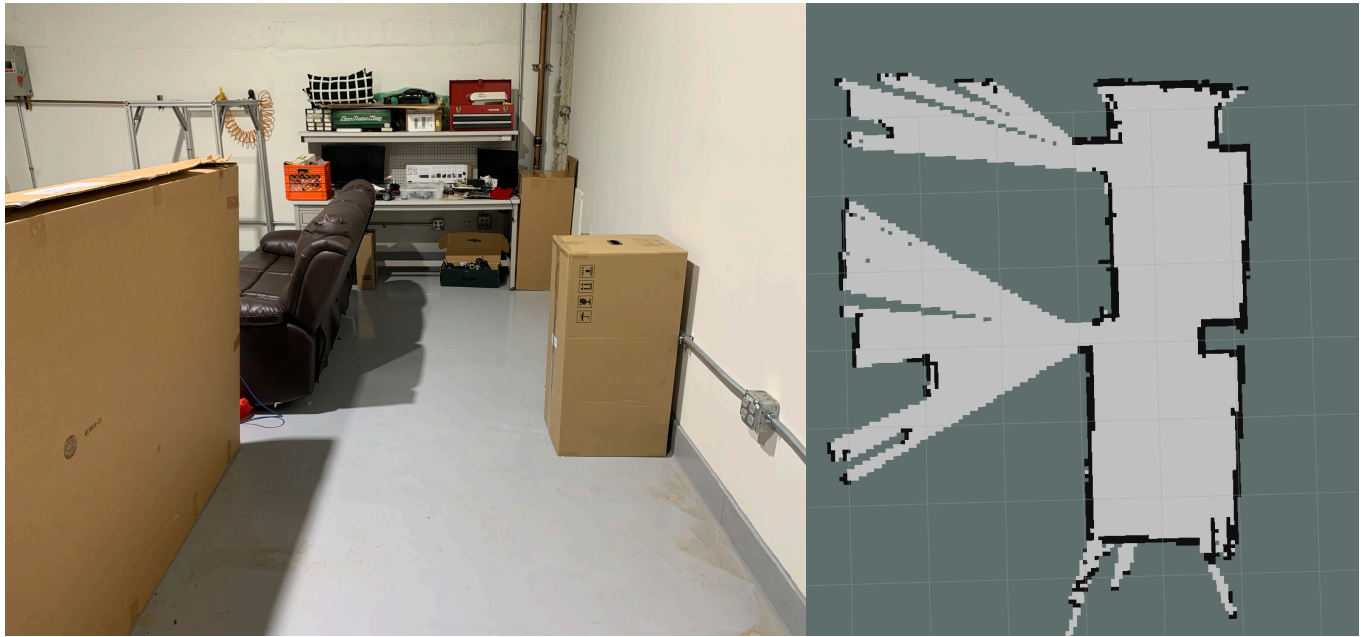
Figure 1. The New Testing Area with its Map



Figure 2. Visualization of Localization result

From the figure above, the visualization of the AMCL output is shown. The red arrow is the estimated odometry vector of the robot base, with the pink ellipse as the uncertainty covariance. It can also be seen that the red LiDAR scans are mapped correctly with respect to the map frame, aligning well with the boundaries of the room.

## Challenges:

The major challenge I encountered was to resolve all the issues related to frame transformations. The ROS TF package provides a convenient interface to deal with coordinate frame transformations. However, all the frames need to be defined and initialized properly, with aligned timestamps, such that the TF can work as expected. I spent some time and effort to make sure the URDF provides all essential static transformations, and make the odometry transformations output by the turtlebot package aligned well with the hector slam package and the AMCL package such that they can be integrated together.

## Teamwork:

I mainly worked with Jorge on fixing remaining issues in the controller and state machine, as well as discussing about how to utilize the output map from the hector slam package to do exploration and planning efficiently.

Besides, everyone worked together to clean up and set up our new testing location, with furnitures and boxes to mark the boundaries, and to act as obstacles.

## Future Plans:

We will be focusing on integration of each subsystems in the last month of the project course. As my individual goal, I will work with Jorge to implement and test the exploration algorithm, and integrate it with our robot controller and the state machine.